

### Smart Lowside Power Switch

#### Features

- Logic Level Input
- Input Protection (ESD)
- Thermal Shutdown
- Overload protection
- Short circuit protection
- Overvoltage protection
- Current limitation
- Maximum current adjustable with external resistor
- Current sense
- Status feedback with external input resistor
- Analog driving possible

#### Application

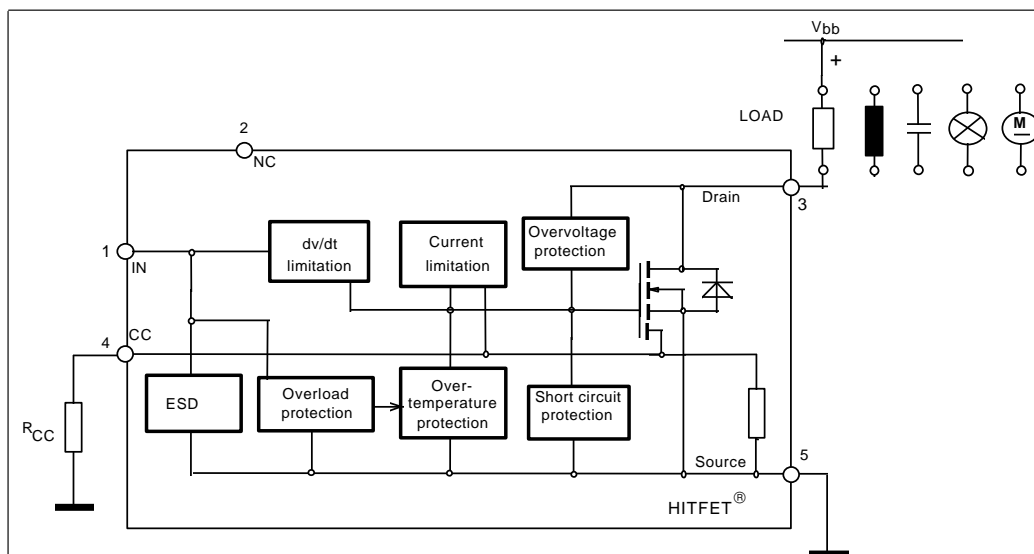
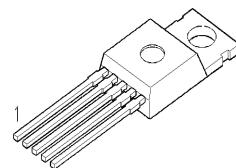
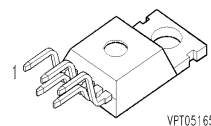
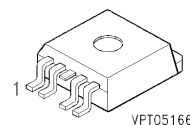
- All kinds of resistive, inductive and capacitive loads in switching or linear applications
- $\mu$ C compatible power switch for 12 V and 24 V DC applications
- Replaces electromechanical relays and discrete circuits

#### General Description

N channel vertical power FET in Smart SIPMOS® chip on chip technology. Fully protected by embedded protected functions.

#### Product Summary

Drain source voltage	$V_{DS}$	60	V
On-state resistance	$R_{DS(on)}$	28	m $\Omega$
Current limit	$I_{D(lim)}$	6	A
Nominal load current	$I_{D(ISO)}$	12	A
Clamping energy	$E_{AS}$	4000	mJ



### Maximum Ratings at Tj = 25 °C unless otherwise specified

Parameter	Symbol	Value	Unit
Drain source voltage	$V_{DS}$	60	V
Drain source voltage for short circuit protection $R_{CC} = 0 \Omega$ without $R_{CC}$	$V_{DS(SC)}$	15 50	
Continuous input current <sup>1)</sup> $-0.2V \leq V_{IN} \leq 10V$ $V_{IN} < -0.2V$ or $V_{IN} > 10V$	$I_{IN}$	no limit $ I_{IN}  \leq 2$	mA
Operating temperature	$T_j$	- 40 ... +150	°C
Storage temperature	$T_{stg}$	- 55 ... +150	
Power dissipation $T_C = 25 \text{ °C}$	$P_{tot}$	149	W
Unclamped single pulse inductive energy $I_{D(ISO)} = 12 \text{ A}$	$E_{AS}$	4000	mJ
<b>Electrostatic discharge voltage</b> (Human Body Model) according to MIL STD 883D, method 3015.7 and EOS/ESD assn. standard S5.1 - 1993	$V_{ESD}$	3000	V
Load dump protection $V_{LoadDump}^{2)} = V_A + V_S$ $V_{IN} = \text{low or high}; V_A = 13.5 \text{ V}$ $t_d = 400 \text{ ms}, R_l = 2 \Omega, I_D = 0.5 \cdot 12 \text{ A}$ $t_d = 400 \text{ ms}, R_l = 2 \Omega, I_D = 12 \text{ A}$	$V_{LD}$	100 84	
DIN humidity category, DIN 40 040		E	
IEC climatic category; DIN IEC 68-1		40/150/56	

### Thermal resistance

junction - case:	$R_{thJC}$	0.84	K/W
junction - ambient:	$R_{thJA}$	75	
SMD version, device on PCB: <sup>3)</sup>	$R_{thJA}$	45	

<sup>1</sup>A sensor holding current of 500  $\mu\text{A}$  has to be guaranteed in the case of thermal shutdown (see also page 3)

<sup>2</sup> $V_{LoadDump}$  is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

<sup>3</sup>Device on 50mm\*50mm\*1.5mm epoxy PCB FR4 with 6cm<sup>2</sup> (one layer, 70  $\mu\text{m}$  thick) copper area for Drain connection. PCB is vertical without blown air.

### Electrical Characteristics

Parameter at T <sub>j</sub> =25°C, unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
Characteristics					
Drain source clamp voltage T <sub>j</sub> = - 40 ...+ 150°C, I <sub>D</sub> = 10 mA	V <sub>DS(AZ)</sub>	60	-	73	V
Off state drain current V <sub>DS</sub> = 32 V, T <sub>j</sub> = -40...+150 °C, V <sub>IN</sub> = 0 V	I <sub>DSS</sub>	-	-	20	µA
Input threshold voltage I <sub>D</sub> = 2,7 mA	V <sub>IN(th)</sub>	1.3	1.7	2.2	V
Input current - normal operation, I <sub>D</sub> <I <sub>D(lim)</sub> : V <sub>IN</sub> = 10 V	I <sub>IN</sub> (1)	-	35	100	µA
Input current - current limitation mode, I <sub>D</sub> =I <sub>D(lim)</sub> : V <sub>IN</sub> = 10 V	I <sub>IN</sub> (2)	-	270	500	
Input current - after thermal shutdown, I <sub>D</sub> =0 A: V <sub>IN</sub> = 10 V	I <sub>IN</sub> (3)	1000	2500	4000	
Input holding current after thermal shutdown T <sub>j</sub> = 25 °C T <sub>j</sub> = 150 °C	I <sub>IN(H)</sub>	500 300	- -	- -	
On-state resistance I <sub>D</sub> = 12 A, V <sub>IN</sub> = 5 V, T <sub>j</sub> = 25 °C I <sub>D</sub> = 12 A, V <sub>IN</sub> = 5 V, T <sub>j</sub> = 150 °C	R <sub>DS(on)</sub>	- -	31 52	34 68	mΩ
On-state resistance I <sub>D</sub> = 12 , V <sub>IN</sub> = 10 V, T <sub>j</sub> = 25 °C I <sub>D</sub> = 12 , V <sub>IN</sub> = 10 , T <sub>j</sub> = 150	R <sub>DS(on)</sub>	- -	25 45	28 56	mΩ
Nominal load current (ISO 10483) V <sub>IN</sub> = 10 V, V <sub>DS</sub> = 0.5 V, T <sub>C</sub> = 85 °C	I <sub>D(ISO)</sub>	12			A

### Electrical Characteristics

Parameter at $T_j = 25^\circ\text{C}$ , unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	

### Characteristics

Initial peak short circuit current limit $V_{IN} = 10\text{ V}$ , $V_{DS} = 12\text{ V}$	$I_{D(SCP)}$	-	160	-	A
Current limit <sup>1)</sup> $V_{IN} = 10\text{ V}$ , $V_{DS} = 12\text{ V}$ , $t_m = 350\text{ }\mu\text{s}$ , $T_j = -40\dots+150\text{ }^\circ\text{C}$ , without $R_{CC}$ $V_{IN} = 10\text{ V}$ , $V_{DS} = 12\text{ V}$ , $t_m = 350\text{ }\mu\text{s}$ , $T_j = -40\dots+150\text{ }^\circ\text{C}$ , $R_{CC} = 0\text{ }\Omega$	$I_{D(lim)}$	6 100	12 130	25 170	

### Dynamic Characteristics

Turn-on time $V_{IN}$ to 90% $I_D$ : $R_L = 2,2\text{ }\Omega$ , $V_{IN} = 0$ to $10\text{ V}$ , $V_{bb} = 12\text{ V}$	$t_{on}$	-	40	100	$\mu\text{s}$
Turn-off time $V_{IN}$ to 10% $I_D$ : $R_L = 2,2\text{ }\Omega$ , $V_{IN} = 10$ to $0\text{ V}$ , $V_{bb} = 12\text{ V}$	$t_{off}$	-	70	170	
Slew rate on 70 to 50% $V_{bb}$ : $R_L = 2,2\text{ }\Omega$ , $V_{IN} = 0$ to $10\text{ V}$ , $V_{bb} = 12\text{ V}$	$-dV_{DS}/dt_{on}$	-	1	3	$\text{V}/\mu\text{s}$
Slew rate off 50 to 70% $V_{bb}$ : $R_L = 2,2\text{ }\Omega$ , $V_{IN} = 10$ to $0\text{ V}$ , $V_{bb} = 12\text{ V}$	$dV_{DS}/dt_{off}$	-	1	3	

### Protection Functions

Thermal overload trip temperature	$T_{it}$	150	165	-	$^\circ\text{C}$
Unclamped single pulse inductive energy $I_D = 12\text{ A}$ , $T_j = 25\text{ }^\circ\text{C}$ , $V_{bb} = 32\text{ V}$ $I_D = 12\text{ A}$ , $T_j = 150\text{ }^\circ\text{C}$ , $V_{bb} = 32\text{ V}$	$E_{AS}$	4000 900	- -	- -	mJ

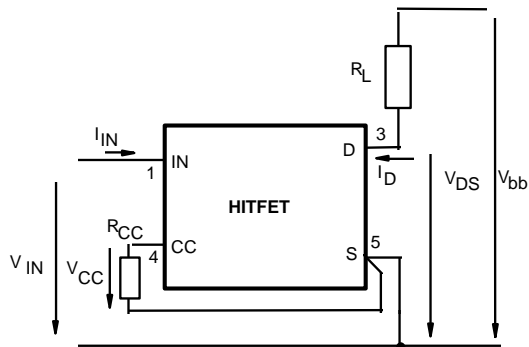
### Inverse Diode

Inverse diode forward voltage $I_F = 5 \cdot 12\text{ A}$ , $t_m = 300\text{ }\mu\text{s}$ , $V_{IN} = 0\text{ V}$	$V_{SD}$	-	1.13	-	V
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<sup>1)</sup> Device switched on into existing short circuit (see diagram Determination of  $I_{D(lim)}$ ). Dependant on the application, these values might be exceeded for max. 50  $\mu\text{s}$  in case of short circuit occurs while the device is on condition

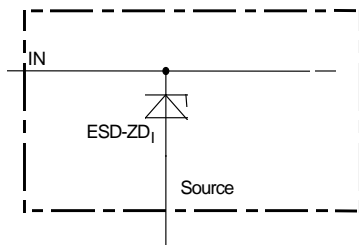
## Block Diagramm

### Terms



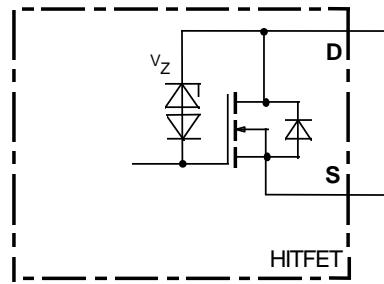
The ground lead impedance of  $R_{CC}$  should be as low as possible

### Input circuit (ESD protection)

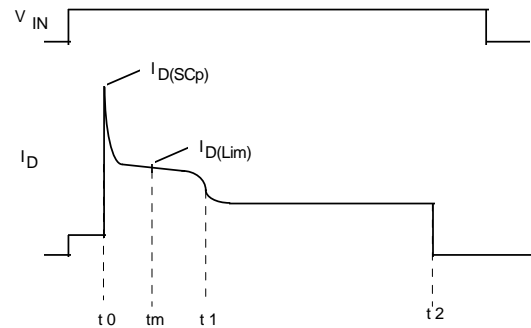


ESD zener diodes are not designed for DC current  $> 2 \text{ mA}$  @  $V_{IN} > 10 \text{ V}$ .

### Inductive and overvoltage output clamp



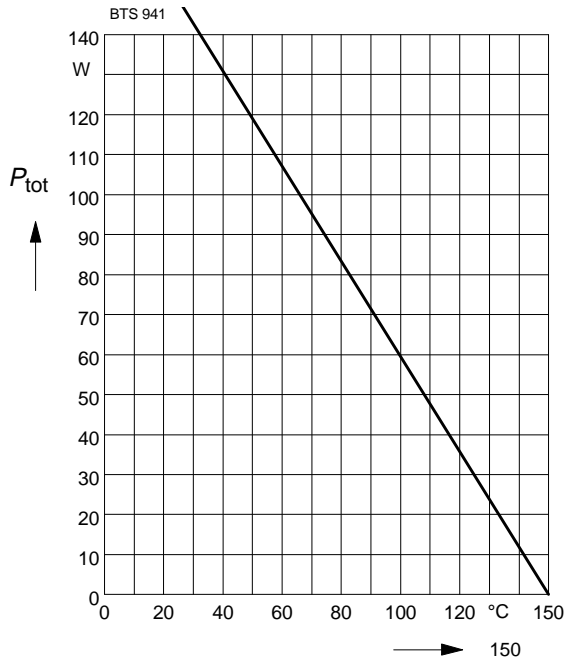
### Short circuit behaviour



- $t_0$ : Turn on into a short circuit
- $t_m$ : Measurementpoint for  $I_{D(Lim)}$
- $t_1$ : Activation of the fast temperature sensor and regulation of the drain current to a level where the junction temperature remains constant.
- $t_2$ : Thermal shutdown caused by the second temperature sensor, achieved by an integrating measurement.

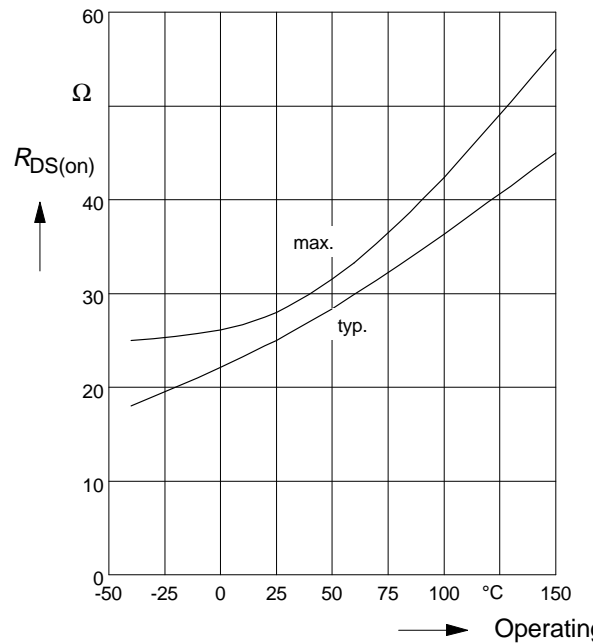
### Maximum allowable power dissipation

$$P_{\text{tot}} = f(T_c)$$



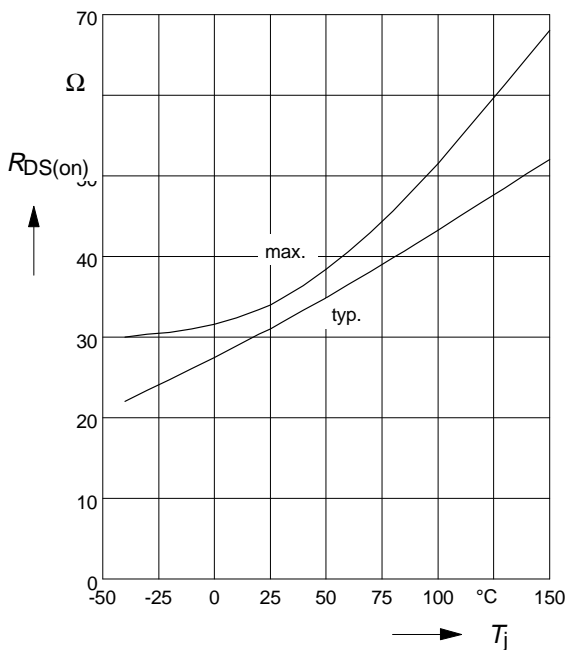
### On-state resistance

$$R_{\text{ON}} = f(T_j); I_D=12\text{A}; V_{\text{IN}}=10\text{V}$$



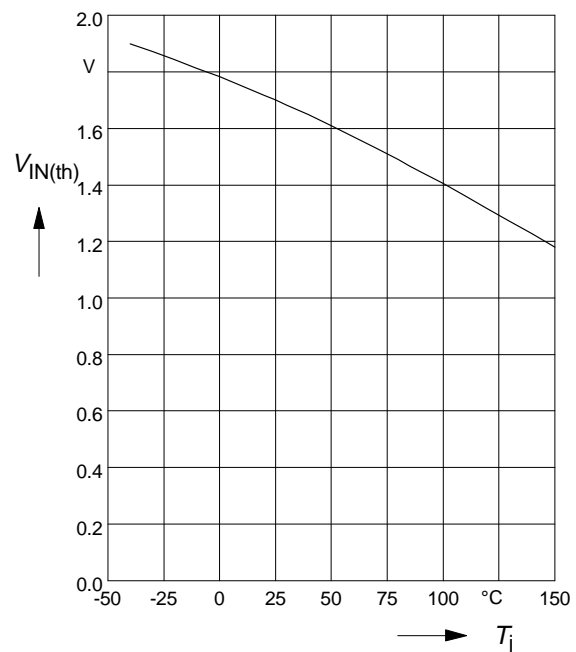
### On-state resistance

$$R_{\text{ON}} = f(T_j); I_D=12\text{A}; V_{\text{IN}}=5\text{V}$$



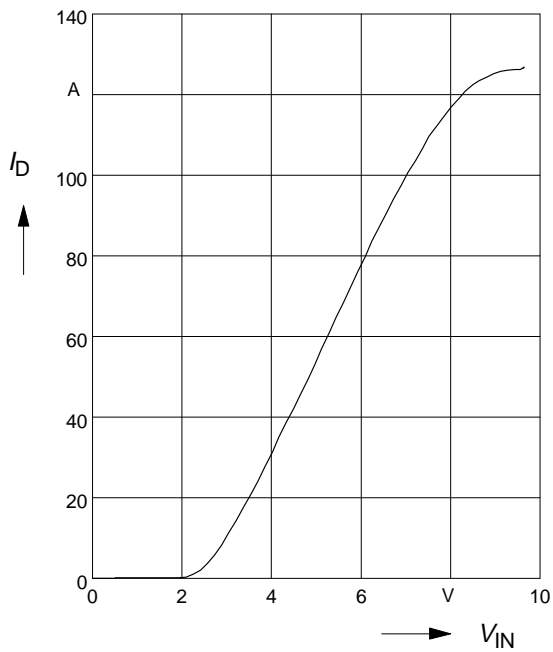
### Typ. input threshold voltage

$$V_{\text{IN(th)}} = f(T_j); I_D=2,7\text{A}; V_{\text{DS}}=12\text{V}$$



### Typ. transfer characteristics

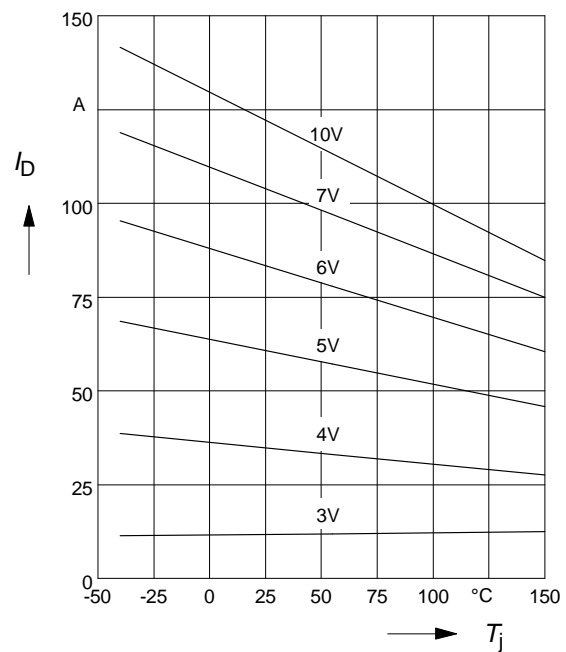
$I_D = f(V_{IN})$ ;  $V_{DS}=12V$ ;  $T_j=25^\circ C$



### Typ. short circuit current

$I_{Dlim} = f(T_j)$ ;  $R_{CC}=0\Omega$ ,  $V_{DS}=12V$

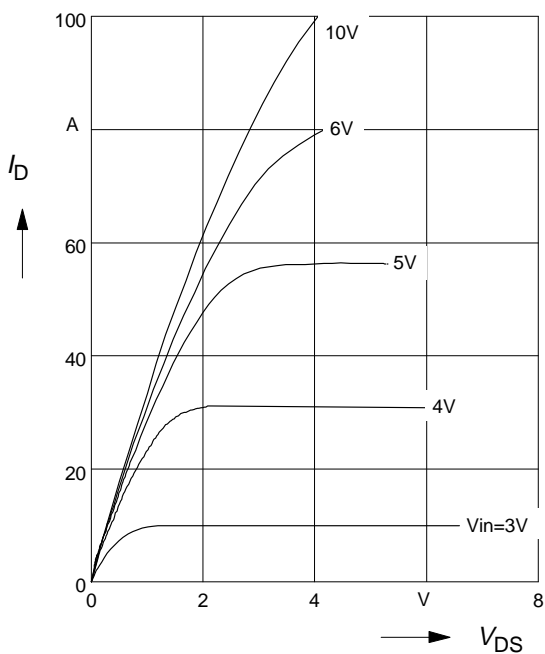
Parameter:  $V_{IN}$



### Typ. output characteristic

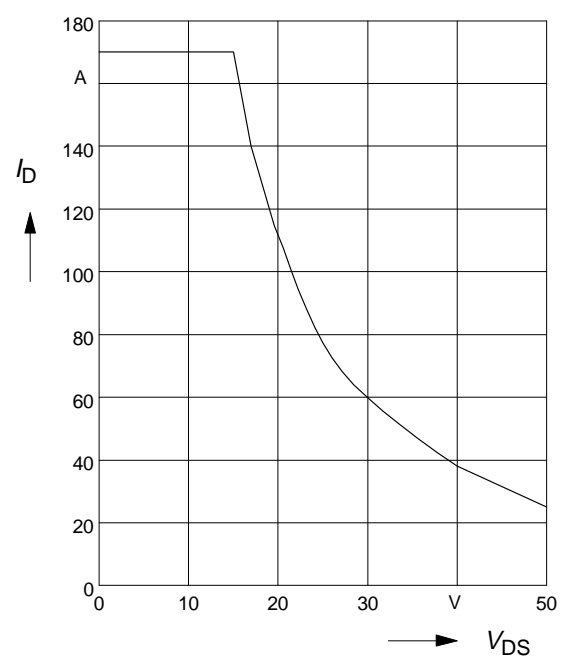
$I_D = f(V_{DS})$ ;  $T_j=25^\circ C$

Parameter:  $V_{IN}$



### Safe Operating Area

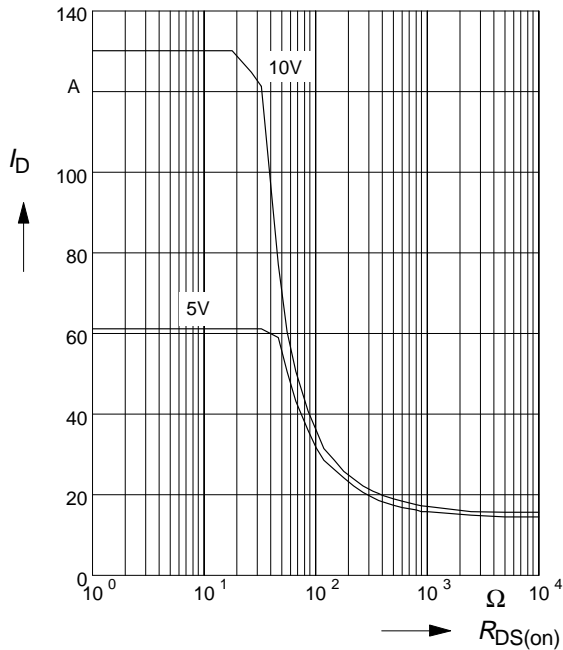
$I_{D(SC)} = f(V_{DS})$ ;  $T_j=25^\circ C$



## Typ. current limit versus $R_{CC}$

$$I_{D(lim)} = f(R_{CC}); T_j = 25^\circ\text{C}$$

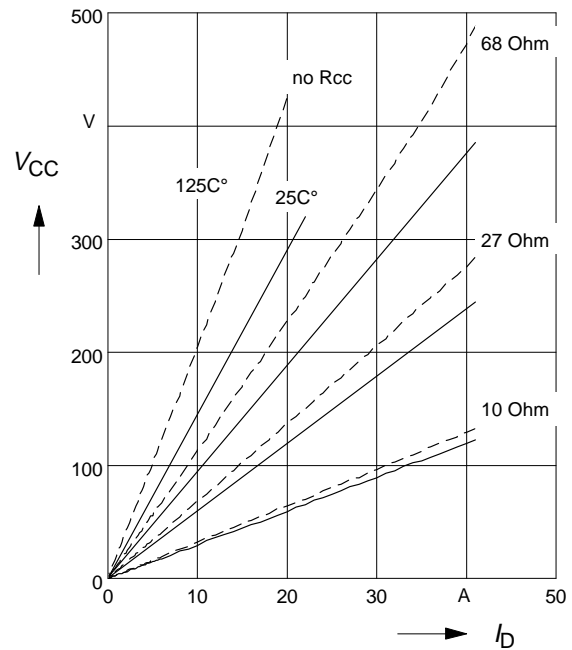
Parameter:  $V_{IN}$



## Typ. current sense characteristics

$$V_{CC} = f(I_D); V_{IN} = 10V$$

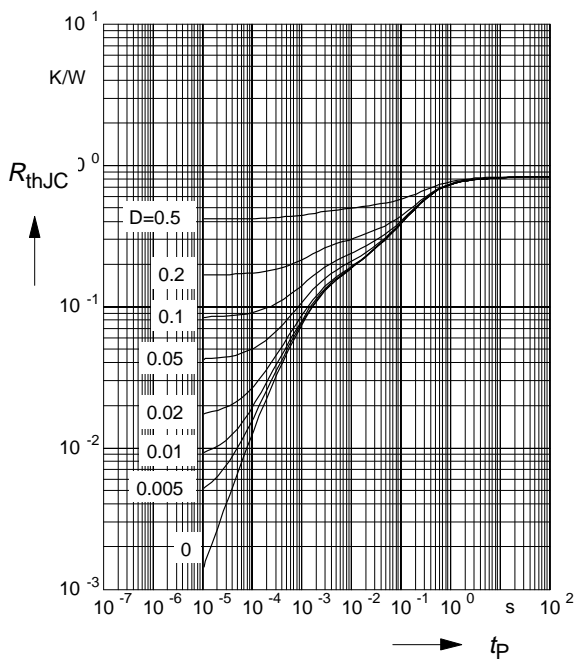
Parameter:  $R_{CC}, T_j$



## Transient thermal impedance

$$Z_{thJC} = f(t_p)$$

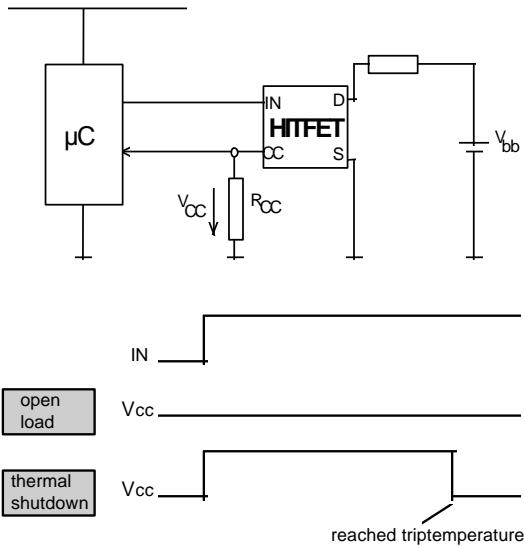
Parameter:  $D = t_p / T$





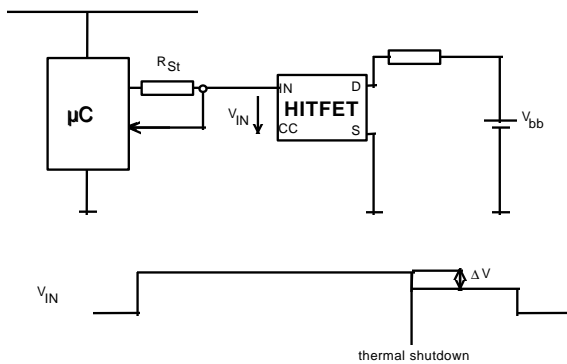
## Application examples:

### Current Sense Features and Status Signals



The accuracy of  $V_{CC}$  is at each temperature about  $\pm 10\%$

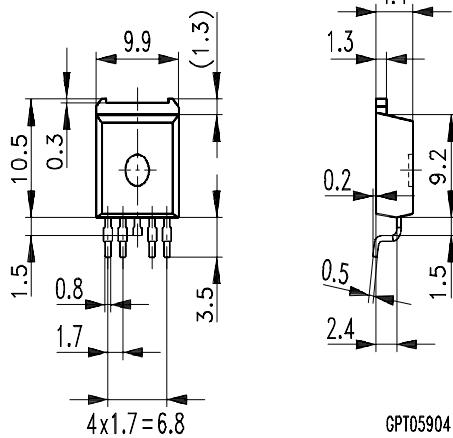
### Status signal of thermal shutdown by monitoring input current



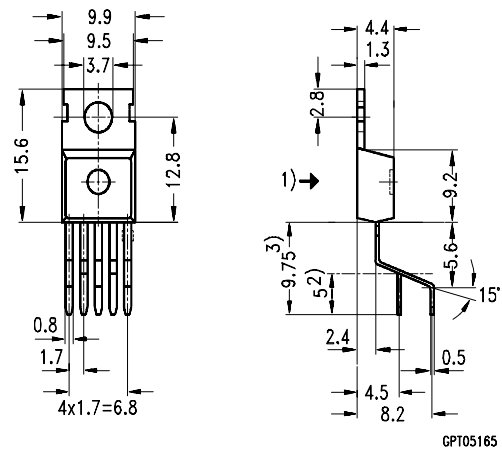
$$\Delta V = R_{ST} * I_{IN(3)}$$

### Package and ordering code all dimensions in mm

Ordering code: Q67060-S6702-A4

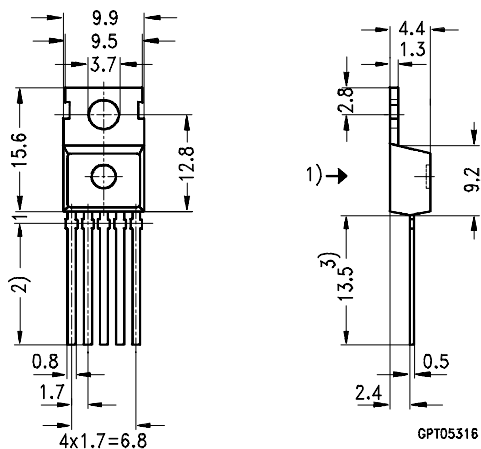


Ordering Code: Q67060-S6702-A2



- 1) shear and punch direction no burrs this surface
- 2) min. length by tinning
- 3) max. 11 mm allowable by tinning

Ordering Code: Q67060-S6702-A3



- 1) punch direction, burr max. 0.04
- 2) dip tinning
- 3) max. 14.5 by dip tinning press burr max. 0.05

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